DESIGN CYCLE

A step by step guide

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Criterion A – Inquiring & Analyzing

Ai) Explain and justify the need for a solution to a problem for a specified client/target audience

Once students have been presented with the situation, they will need to identify a problem to solve, explain it and justify the need to solve it.

Students may ask the following questions to identify a problem from the situation

- What is the nature of the problem?
- Who is it a problem for?
- Where is the problem occurring?
- What is the cause of the problem?
- What effect is the problem having?

Strategies to answer the above questions may include:

- Identifying a target user by applying brainstorming or mind-mapping techniques
- Interviewing, surveying and/or polling potential clients
- Observing, filming and/or photographing users interacting with a product
- Collecting data from experts to confirm there is a real need for a solution to the problem
- Seeing the situation from the user's/client's point of view

Aii) Identify and prioritize the primary and secondary research needed to develop a solution to the problem

Students are encouraged to formulate a list of questions in order of importance that will help prioritize and guide their research. Students will need to identify:

- The questions that need to be answered to solve the problem
- The relevant data that needs to be collected
- Where the data will be sourced from
- Whether sources are primary or secondary
- Which sources are essential, and which are desirable.

Primary Research (Direct: First-hand research)	Secondary Research (Indirect: Desk research)
All primary research is carried out by the student, who collects his or her own data.	Secondary research involves using data collected by other people.

Examples include: • conducting interviews, surveys and polls with a target audience and/or client • interviewing experts over the telephone • writing letters or emails asking for specific information about a product from a client • observing users interacting within the situation and making notes • analyzing products that have things in common with the problem • investigating the work of other designers of existing products • conducting market research such as surveys, questionnaires and interviews through focus groups • experimenting with materials, tools and processes	Examples include: • analyzing data from a website or book • reading accounts of a problem written by another person • analyzing articles in magazines, journals and newspapers • downloading data from a marketing website • viewing videos about how to use materials, tools and processes.

Aiii) Analyze a range of existing products that inspire a solution to the problem

There may be a wide range of products that solve similar problems to the one assigned to students. Before beginning to develop a specification and designs, students need to identify existing products that solve a similar problem, could partially solve their problem or could give them ideas on how to solve their problem. Students will need to employ a range of strategies to analyse these products, such as:

- Identification of and interaction with similar products when out shopping
- Attribute listing of existing products
- SWOT analysis (strengths, weaknesses, opportunities and threats)
- Functional analysis
- Aesthetic analysis
- Graphical disassembly analysis
- Performance testing of products
- Evaluation of past student projects
- Secondary research through product reviews on consumer websites, buying guides or magazines
- Summary of customer reviews on commercial websites.

Aiv) Develop a detailed design brief which summarizes the analysis of relevant research

At this point, students have collected a great deal of data that requires analysis and summary to inform the design of the solution and be useful. The analysis and summary must be presented in a ***design brief***, a series of detailed paragraphs that present only the useful information.

The brief shouldn't solve the problem at this stage, but instead outline what the student intends to design to solve the problem, provide answers to each of the research questions, and clarify the essential and desirable features of a solution. It should also state any determined values that the design must meet, such as the following:

- When designing a bird house, the student may have researched the size of desired birds and therefore determined the size of the entry hole to the bird house.
- When designing a new noodle product, the student may have determined the "base" recipe for making the noodles as part of his or her research.
- When designing a web page, the student may have identified certain fonts or images that need to be included.
- When designing a video game, the student may have identified particular sprites that he or she will use to represent the main characters in the game.

When writing a **design brief**:

Students should:	Students should NOT:
• present information concisely • explain how and why the information is relevant to solving the problem • evaluate the validity of the data • present their research in an appendix • cite all sources of information using appropriate conventions.	• write large paragraphs of text • include statements that do not relate to solving the problem • make statements without evidence from expert opinion or data • include all of their research within the body of the project.

Criterion B – Developing Ideas

Bi) Develop a design specification which clearly states the success criteria for the design of a solution

Students should be presented with this strand if they have completed objective A and move on to objective B—they have carried out their research and developed a summary of their findings.

What is a **design specification**?

- A specification is a set of considerations, constraints and requirements for a solution: what the solution must or must not have to be successful. A specification is not a description of the outcome. It should demonstrate that students understand the needs of the problem that they have identified. Every aspect of a specification must be specific, measurable, achievable, realistic and testable (SMART).
- The specification should be directly connected to the design brief. Writing a specification can be a difficult job if the design brief is not well researched and written. If a solution or design fails to meet an aspect of the specification, it can be considered that it has not met the criteria for success.
- Students will need to refer back to the specification throughout the project, particularly when developing ideas and evaluating the solution.
- When writing a specification, students should consider including details addressing the aspects in the next table:

Aesthetics	Consider appearance, style, colour, shape/form, texture, pattern, finish, layout.
Cost	Is there a maximum cost? Is this a material cost/time cost/selling cost?
Customer	Who it is for? What is the target user's age, gender, socio-economic background?
Environmental considerations	Where will the solution be used? How will the design directly or indirectly affect the environment?
Function	What it must do? What is its purpose? Where will the product be stored? How easily can it be used/maintained?
Manufacturing	What resources are available? Are there limitations as to how this can be created? How much time is needed to create the design?
Materials	What materials are available? What properties do the materials need to have?
Safety	What safety factors need to be incorporated into the design?
Size	Are there any specific sizes that need to be considered? What "human factors" need to be considered? What anthropometric data needs to be considered?

Given a final product to students, they must work backwards to create a specification by answering a few questions related to the product.

- What was the problem to be solved?
- What questions may the designer have asked to be able to design the product?
- What do you think the design specifications of that product include?
- What other questions could have been asked to enhance the effectiveness of the product?

Changing specifications during a unit of work

- Students may have opportunities to develop their specification further as they continue through the unit of work. Whether students modify their specification should be taken into account by the teacher, and the final version of the specification should be incorporated into the assessment of students' performance.
- Changes in a specification should be justified through additional research that students may need to conduct as a result of finding that an aspect of a specification is not appropriate.

Bii) Develop a range of feasible design ideas which can be correctly interpreted by others

For both digital and product design, a natural starting place when designing is with a pencil and sheet of paper, developing **rough sketches** of potential solutions. Students should be encouraged to focus on getting the basic building blocks of ideas sketched out in short, concentrated bursts. These initial ideas should focus on generating a range of different solutions to the problem.

Students should then identify which initial ideas should be developed further. This could be done through a range of strategies, including:

- further, **more detailed sketches** that start to develop ideas with direct reference to the specification
- **detailed annotation** that allows students to explore and communicate their own thinking through annotation
- making of simple card and CAD models and simulations used to test ideas and ensure they meet the specification.

Throughout the course, teachers should ensure that students have the opportunity to practice different strategies and techniques to communicate and develop ideas.

Technique/strategy	Digital design
Initial concept sketching	Layout drawing, Storyboarding, Scripts for audio
Development drawings	Detailed layout page design, Visual mock-ups, Web trees/maps Detailed audio script including directions on pitch, sounds, pause lengths, pace and music
Modelling	Mock-ups, Prototypes, Simulations

What does it mean to develop an idea? How do I present this information?

Designers do not come up with a single, static idea that solves all aspects of a problem; designs are developed over time in an iterative fashion. Students should record their iterative development through design sketching, modelling, refining and testing. This is all part of design development.

A ***range*** is not quantifiable. The number of ideas students will create depends on the complexity of the problem, age, level of experience and time. When students ask how many ideas they should generate, the simple answer is: *as many as it takes to solve the problem and to develop a design that meets all of the design specifications*.

When developing their design ideas, students must always be working towards the goal of designing a solution to the problem, for which the requirements have been defined through the design specification. Therefore, they must work towards developing at least one design to meet the specification.

Students should develop, or refine, every detail, including:

- the exact size and shape of individual components
- the required and/or available materials
- how the components fit together to create the whole
- the required and/or available tools and equipment
- aesthetics (color, texture, shape, form, line, balance, finish)
- how the user will interact with the solution
- aspects relating to safety and accessibility.

What is a feasible idea?

A ***feasible idea*** is an idea students could successfully make independently in the given time, with their skills, and with the resources at their disposal.

Students can include ideas in their design folio that do not achieve all specifications successfully, but these ideas should lead to feasible ideas through design development or be constructively criticized through annotation to highlight weaknesses and suggest improvements.

To ensure that ideas are feasible, they may need to be tested using **mock-ups** or **models**.

Depending on the type of project, students can use mock-ups or models to prove concepts or test whether their ideas or solutions will work. This is part of the development of ideas. Students should explain why they are making the mock-up or model and how it has helped them solve any design problems. They should provide evidence of their development by photographing the mock-ups or models and include the results of testing as evidence in the design folio. Students should also clearly state how this testing has informed further development of the designs.

The following questions may help students reflect on their design ideas:

- Do I need to do more research to complete my design? For example, how do I join one part of my design to another?
- Does the school have the resources (tools, machinery, hardware, software or materials) to make the design?
- Do I have the skills to make this design? Can I gain the skills to make this design?
- Will I have to get any resources myself? If so, where and when?
- Will I be able to make this design in the time available?

Why is "annotation" important?

Annotation is vital for students to communicate the thinking behind their ideas and how that thinking develops. Simply sketching ideas will not clearly communicate them, as other people looking at these ideas may not interpret them correctly. Teachers may ask the following questions to support students in writing their annotation:

- How did you come up with the idea? Did something influence your thinking?
- What materials do you think should be used, and why? Are the materials available?
- How could the idea be made? What tools, equipment and processes would you use?
- Could the design be made in the time available and with your skills?
- Would it cost too much?
- Is it safe?
- Do you think your client would like the idea?
- Why did you choose this color/texture?

Other elements students should incorporate into their annotation include:

- how one idea led to another?
- how they could improve/develop their design ideas?
- whether they need to do more research, for example, into materials?
- whether the client thinks their ideas are suitable?

Do all ideas need to be evaluated against the specification?

When designing, students should develop their ideas towards meeting the design specification, resulting in their final design meeting the criteria. Students should constantly consider the design specifications as they design and reflect this in their annotation. An evaluation of the final design against the specification should be included as part of the design's selection.

Correct interpretation of design ideas

The correct interpretation of design ideas is vital for clear communication of ideas between a designer, client, target audience and manufacturer.

Students are assessed on the quality of their design communication through strand ii, encompassing their sketching, modelling, refinement, development, testing and annotation of designs. If the teacher cannot determine or interpret the design, it is not sufficiently represented, and the design thinking has not been clearly articulated.

Students will need to combine their design sketching, mock-ups and models, CAD and annotation to clearly articulate their ideas.

Biii) Present the final chosen design and justify its selection

When presenting the chosen design

When presenting the final chosen design, students must provide a clear image of that design, which clearly shows its details and features. This image should be presented as a final illustration, separate to any developmental work.

For **product design**, students create a clear, well-presented illustration of the final chosen design that highlights details such as color, form, texture, proportion, how the solution functions and all its features.

For **digital design**, students create a clear, well-presented illustration of the final chosen design that highlights details such as color, form, fonts, layout, how the solution is interacted with and its features.

Selecting and justifying the chosen design

When working with a client or target market, **feedback** is a vital source for selecting a design to take forward for prototyping. Students should formulate questions, which could be delivered in the form of an interview or survey, to find out which design their client likes the best and why. They then summarize findings in a written statement.

The questions should focus on gaining feedback related to the aspects of the specification that have qualitative/subjective parameters. Students should recognize that clients may change their minds at this point, and therefore the specification; they may have to redevelop their chosen idea.

Students will also need to critically evaluate the chosen idea against each specification and justify how the chosen design satisfies the specification. If the design does not meet the design specification, it needs further development—or the specification needs redevelopment.

Biv) Develop accurate and detailed planning drawings/diagrams and outline the requirements for the creation of the chosen solution

Why do I need a planning drawing/diagram?

Typically, designers will develop their ideas and create detailed drawings/diagrams for a manufacturer to create a final prototype/sample/model. To get the correct solution created to the correct specification, designers must communicate their final chosen solution to a manufacturer very clearly. Planning diagrams and drawings are communication tools that are essential for good design.

When designing solutions to problems, students need to ensure that they have a very clear idea of what they will create. There is often a great difference between the "idea" and the "realized solution". To ensure that the idea and realized solution are the same, students should consider all aspects of creating the product. Through the development of design ideas, students should have identified:

- which materials will be required (digital or tangible, standard or customized components etc.)
- which tools and processes will be used (hardware, software, techniques etc.)
- the size, tolerances, position (layout) and assembly of components
- the overall visual appearance.

These elements must be defined clearly through planning drawings or diagrams that are sufficient for someone else to follow.

What modes and media are appropriate for planning drawings/diagrams?

- Details of components (identification, size/scale, color, fonts, and so on)
- Screenshots demonstrating visual layout
- Storyboards
- Web trees and details of identified components (text, images, fonts, audio, video, sprites) to be used
- Layouts/templates designed by the student
- Interface layouts
- Detailed sketches (graphic design models)

Standard components/raw materials/ingredients, whether physical or digital, need to be identified. Where students select a standard (pre-made) component, they must consider how the standard component will be combined with any components that they need to create themselves.

Criterion C – Creating the Solution

Ci) Construct a logical plan that describes the efficient use of time and resources, sufficient for peers to be able to follow to create the solution.

In objective C, the role of the student switches from designer to prototype-developer or manufacturer. Objective C focuses on the realization or creation of a solution to a problem.

One of the most difficult aspects of design is to take an idea from paper and create a product that someone can interact with: a solution to a problem. In objective B, students developed planning drawings and/or diagrams to clearly depict what they are making. In this first strand of objective C, students detail how they will make their solution.

By constructing a logical plan that details the steps required to make a solution, students will demonstrate their knowledge and understanding about how solutions can be made.

What are resources?

Resources can be categorized in two ways: **materials** and **tools**.

It is simple to identify tangible materials such as hardwood, nylon or cornstarch; however, it can become more problematic to determine digital materials. When identifying digital materials, students should consider text, fonts, images, audio, video, animation, sprites and icons.

For digital design, tools include both software and hardware (input, processing and output devices). For product design, tools include hand tools, machinery, CAD software and CAM hardware.

Quality control and assurance

Quality assurance covers all materials from design to documentation. It includes the regulation of quality of raw materials, assemblies, products and components, services related to production and management, and inspection processes.

Quality control manifests itself in the development checking and testing of systems to ensure that products or services are designed and made to meet or exceed specifications.

A **logical plan** can be expressed with a

- flow chart
- Storyboard
- step by step plan

Step	Process (including quality control and health and safety considerations)	Required resources	Materials	Time to complete
1				
2				

- Gantt chart

  A Gantt chart is a project-management tool used to provide an overview of a process. The Gantt chart plots divide the manufacture of a product into small tasks. It indicates the time estimated for each of these tasks and the resources required. It does not provide a detailed set of instructions, but instead is an overview to self-assess progress with a project. Students should be encouraged to indicate when each task is complete.

Task	Description	Tools required	Week 1	Week 2	Week 3	Week 4

The following questions can help students consider their planning.

- Does your plan contain a sequence of logical steps?
- Is the use of resources explained clearly?
- Have you made sure you have enough time to complete your product?
- Have you given time for practicing or learning a new skill?
- Have you allowed extra time in case something goes wrong?
- Have you considered alternative ways of creating the solution?
- Have you planned for testing at appropriate times in the manufacturing process?

Cii) Demonstrate excellent technical skills when making the solution

To determine the correct level of technical skill a student is operating at, teachers need to consider the complexity of skill demonstrated as well as the level of guidance that the teacher needs to provide the student for him or her to complete the task.

When determining the complexity of skill demonstrated by a student, a number of indicators can be considered.

- **Accuracy** of the solution: Have all parts been made as detailed in the plan? Have all parts been made accurately?
- **Final aesthetic quality** of the solution: Has the student given appropriate attention to detail, considering the final overall look and feel of the solution?

- **Assembly** of the solution: Do all components fit together or combine as detailed in the plan?

When determining the level of guidance and support needed, teachers should consider that students:

- can be given initial guidance and demonstrations by the teacher
- can practice the processes as required
- must work independently when making the solution, if they are to achieve the higher levels
- should demonstrate safe working practices.

For digital design, the level of technical skill demonstrated can be shown through the **functionality** of the assembled solution. For product design, the level of technical skill demonstrated can usually be shown through the functionality and the final finish of the assembled solution.

Ciii) Follow the plan to create the solution, which functions as intended

Students demonstrate that the planning process was sufficiently thorough if the final product matches the planning drawing and no changes were made to the plan, in whatever form it was presented. If the drawings/diagrams and the plan match what has been made, then students have followed the plan.

If a student does not follow the plan, it will usually result in the solution not fully meeting the specification and/or matching the design detailed in the drawings/diagrams.

Civ) Fully justify changes made to the chosen design and plan when making the solution

As students implement their plans, they will often come to a point where they will have to modify the plan or the design. They need to ensure that they detail and justify any changes that they make during the creation process.

If students do not make any changes to their product or plan, this strand does not have to be addressed with evidence. However, if any changes are made, students must address this strand.

Criterion D – Evaluating

Di) Design detailed and relevant testing methods, which generate data, to measure the success of the solution

Testing methods

An effective and authentic measure of a design solution means that the student has tested against **every** aspect of the design specification. These tests can be classified as follows.

Expert appraisal

A person considered an expert in the use of similar products is presented with the solution, given time to interact with the solution and then interviewed on aspects of its success. The expert has particular knowledge and skills that allow him or her to make judgments on the success of the solution. The expert may be the client.

Field trial

A *field trial* is a test of the performance of a solution under the conditions and situation in which it will be used. For example, an interactive information point (developed in HTML) for a museum exhibit may be tested by the exhibit visitors in the museum, structured as a user trial or user observation.

Performance testing

The performance of a solution is tested under the conditions in which it would normally be used. Quantitative data is collected through a variety of tests such as:

- destructive tests assessing impact strength or flammability
- cyclic tests
- measurement of physical properties such as weight and size
- timed tests for web pages to load
- ease of navigation through an interactive story, game or website.

User observation

The user is presented with the solution and is set a task to achieve with little or no guidance. The user's interaction with the solution is observed and recorded.

User trials

The user is presented with the solution and guided on how to use it. The user is asked questions as he or she interacts with the solution or is given a survey to complete. User trials may include focus groups.

The design of interview or survey questions needs to be targeted to draw out responses that assess the solution against the specification.

Collecting data

Both types of data collected through testing are considered **primary sources** of data.

Qualitative data deals with quality and is data gathered as descriptions. This data tends to be subjective and can be converted to a numerical value, for example, "I like the overall shape of the solution, it fits my hand well, I would give it a 9 out of 10 for comfort" or "The layout of the webpage looks intuitive, it looks easy to navigate and the use of negative space makes it clear. I would rate the clarity of the page as 8 out of 10."

Tests that can be used to obtain qualitative data include:

- using a questionnaire to find out if the target audience likes the look of a product
- surveying students to find out which parts of a video game they found too easy and which were too difficult
- working with a taste panel to find out if a target audience likes a food product
- interviewing an expert after he or she has interacted with a solution
- performing a user trial by giving a toy to children to play with and observing reactions.

Quantitative data deals with quantity and is gathered as definite values, typically a numerical value. This data is objective and can be measured, for example, "All information in the database has to be a maximum of 3 clicks away" or "The overall cost of the materials can be no more than €45."

Tests that can be used to obtain quantitative data include:

- timing users who are tasked with finding a particular piece of information on a website
- measuring a product to ensure it is the correct size and within weight limits
- beta-testing interactive media to find bugs
- running performance tests to determine the strength of a product
- checking the capacity of a storage device
- counting the number of hits on a website over a set period of time.

Dii) Critically evaluate the success of the solution against the design specification

When critically evaluating the success of a solution, students must objectively judge the solution against the specifications. This objective evaluation comes from analyzing the data gathered by carrying out the tests designed.

Students must analyze this data and make conclusions that identify strengths and weaknesses of the solution, along with opportunities for further development.

Specification	Testing method	Evidence from tests
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Specifications	Yes / No	How is it met?
	5/5	
	3/5	

Diii) Explain how the solution could be improved

Through the objective evaluation of their solution, students should have identified weaknesses in their solutions. These weaknesses provide opportunities for further development and allow students to consider how they would refine their solution further. Students can suggest these improvements in many forms, including:

- written text—paragraphs or tables
- diagrams and charts
- annotated photographs/screenshots of the prototype
- sketches

Div) Explain the impact of the solution on the client/target audience

To identify or predict the impact that a solution will have on a client or target audience, students must refer to the original problem, the design brief, the specification and the evaluation. Students should use these aspects to draw conclusions about how well the design brief has been met. These conclusions may be presented in written form, as a list or as a table.

The following questions may help students to explain the impact of the solution of the client or target audience.

- To what extent has the client's or target audience's problem been solved?
- How does this solution improve the client's or target audience's situation?
- To what extent has the design brief been met?
- Are there any negative effects this solution could have?